Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

# ON A MOOTED MATTER IN THE USE OF AN EYE-PIECE IN PHOTOMICROGRAPHY.

A. CLIFFORD MERCER, M. D., F. R. M. S.

At last year's meeting of this Society, the writer opposed the ordinary use of the eye-piece in high-power photomicrography. He held that a sensitive objective nicely adjusted for cover thickness and focused cannot suffer a change in position without having the nicety of its adjustment to some extent vitiated. The ordinary use of the eye-piece in photomicrography involves such a change in position and therefore vitiates to a corresponding degree the resulting image.

Let us see how such a change is so involved. Rays of light leaving a point in an object in focus and entering the microscope pass out of the eye-piece divergent or parallel to enable the normal eye to focus them on the retina. These rays must be divergent or parallel, because only such rays are focused on the retina by a normal eye. Now, as divergent or parallel rays cannot form a real image, the microscope under the foregoing conditions does not project an image on a screen held anywhere above the eye-piece. To get an image above the eye-piece, the divergent or parallel rays are in ordinary practice made convergent, and therefore image-forming, by focusing; and it is this procedure which changes the position of the objective.

On the other hand, Dr. Blackham said, in reply, that when an object is in focus for a normal eye looking through the microscope, a plane can be found somewhere above the eye-piece in which a real image of the object is formed. A second focusing is therefore unnecessary; and the adjustment of the objective is not disturbed. A few members reported that they had secured photomicrographs in this plane. Dr. Blackham undertook to demonstrate the formation of the image by means of a solar microscope in an adjoining room. The prescribed conditions seemed to be met; and, apparently, an image was formed on a screen about ten inches from the eye-piece.

Dr. Blackham's demonstration was accepted as satisfactory and conclusive. He was, however, unable to give, when requested, a diagramatic or theoretical explanation of the formation of the image. Another member had puzzled over the apparent conflict between observation and theory during two years without finding a solution. The chief purpose of this paper is to record a series of experiments by the repetition of which any sufficiently interested microscopist can satisfy himself that Dr. Blackham's demonstration was in some way at fault, that a real image cannot be formed under the prescribed conditions and that the failure to theoretically explain the formation of an image under those conditions was a proper and to be expected result.

*Experiment 1.* The rulings of a stage micrometer, under an inch-and-a-half objective, were focused for a normal eye looking through a horizontally arranged microscope. A screen was placed in contact with the eye-piece and slowly removed to a distance of five feet without finding an image in any plane through which it passed. But so soon as the microscope was racked slightly away from the object, a sharp image appeared on the screen; and, on again looking through the microscope, the lines seen at first had disappeared.

*Experiment 2.* The second experiment was a repetition of the first, excepting that, instead of micrometer rulings approximately lying in a single plane, the object was a somewhat thick section of lung tissue. When the object was in focus for a normal eye looking through the microscope, a blurred image could be seen on the screen. On racking the microscope away from the object, the image on the screen became sharp, while the object as seen through the instrument lost its sharpness. In the former instance the sharp focus was found to be on the nearer surface of the object, while the blurred image was of a deeper plane; and in the second instance *vice versa*.

*Experiment 3.* The dust on the cover glass of a mount, under an inch-and-a-half objective, was focused for a normal eye looking through the microscope. On removing the head, an image of the object beneath the cover glass appeared on the screen about ten inches from the eye-piece.

*Experiment 4.* A nummulite, under a three-inch objective and two-inch eye-piece, was focused for a normal eye looking through the microscope. With this arrangement a sensitized plate was exposed

at ten inches from the eye-piece. Photomicrograph 1 is a print from the resulting negative. The result is as good as could be obtained at any distance from the eye-piece under the prescribed conditions. The microscope was then racked away from the object until a sharp image appeared at the ten-inch distance. A second sensitized plate was exposed. Photomicrograph 2 is a print from the resulting negative. (Photomicrographs 1 and 2 were shown at the meeting. 1 was not in focus. 2 was sharp.)

*Experiment 5.* A physician, 68 years old, with presbyopic eyes and long accustomed to the use of a microscope, focused, without his spectacles, an object as he saw it through the eye-piece. On removing his head, an image of the object appeared on a screen about twenty-seven inches from the eye-piece. A normal eye looking through the microscope could not see the object.

*Experiment 6.* An Abbe test-plate, under an inch-and-a-half objective, was focused for an eye made, as it were, temporarily hypermetropic by wearing a six-inch negative spectacle lens. On removing the head, a sharp image appeared on a screen about ten inches from the eye-piece. The normal eye without the spectacle lens could not see the object on again looking through the microscope.

*Experiment 7.* Delicate imperfections in the lines of an Abbe test-plate, under a Zeiss 1/8-inch objective and a two-inch eye-piece on a horizontally arranged No. 3 Powell and Lealand stand, were focused for a normal eye looking through the microscope. A sharp real image could not be seen in any plane within six feet of the eye-piece. A four-drachm weight was carefully placed on the cap of the eye-piece, when a sharp image of the imperfections appeared on the screen about fifteen inches from the eye-piece. On again looking through the microscope, the imperfections of the virtual image had lost their sharpness. The weight acted on the eye end of the microscope tube as on a lever, and thus slightly tipped up the objective and increased the distance between it and the object.

*Experiment 8.* The dark dots on a light ground of *pleurosigma angulatum*, under a Powell and Lealand 1–12-inch apochromatic and a one-inch compensating eye-piece on a horizontally arranged No. 3 Powell and Lealand stand, were focused for a normal eye looking through the microscope. On removing the head, a blurred image appeared on the screen about fifteen inches from the eye-

piece; but this blurred image presented the reverse appearance of light dots on a dark ground. A one-drachm weight was carefully placed on the cap of the eye-piece, when a sharp image of the dark dots on a light ground appeared on the screen. On again looking through the microscope the dark dots had lost their sharpness. By removing the weight the original conditions were restored. The sharp black dots were once more seen through the microscope, and only blurred white dots on the screen.

Inductions from these experiments are: First, when the microscope is focused for a normal eye on an object approximately a single plane, the instrument does not project a real image of the object above the eye-piece; and, secondly, when the microscope is so arranged as to project a real image of a very thin object on a screen above the eye-piece, the object is not in focus for a normal eye looking through the instrument. These inductions are in harmony with theoretical optics. Observations really opposed to such inductions must fail to find supporting explanations in theoretical optics.

The announced chief purpose of this paper, to record a series of experiments for particular ends, has been attained. A secondary purpose is to call attention to the fact that the recorded experiments also at least suggest explanations of the apparently opposed phenomena brought to the notice of the Society a year ago.

Let us consider Dr. Blackham's apparently contradictory demonstration. The object was a section of animal tissue showing well-injected blood vessels, and therefore necessarily somewhat thick. A normal eye looking through a microscope might focus the nearer surface of such a section and, on removing the head, find a real image of a deeper plane projected on a screen above or beyond the eye-piece. In this instance the virtual and real images would be in a general way alike, and might be carelessly considered images of one and the same plane of the object. I believe those of us who were present and had glimpses of Dr. Blackham's virtual and real images were careless in the way suggested.

In regard to the fact that some members had focused an object looking through the microscope and then, without changing the conditions of the instrument, had secured a photomicrograph of the object beyond the eye-piece, the following suggestions are offered in explanation: The virtual focusing may have been on the nearer surface of the object and the photomicrograph a picture of a deeper

plane; or the observer's eye may have been presbyopic or otherwise hypermetropic; or, in the case of high-power work, in making a connection between the microscope and camera a little weight on the eye end of the microscope tube may have made the necessary alteration in focus; or a virtual image may have been focused with an erect tube when the weight of the eye-piece tends to press the objective toward the object and the photomicrograph secured with a horizontal tube when the weight of the eye-piece tends to tip the objective up and away from the object; or, and finally, in the case of exceptionally faulty correction the paths of the visual rays may have been so different from the paths of the actinic rays that the former may have given a virtual image and the latter a real image under the same conditions of the microscope.

### *Discussion of Dr. Mercer's Paper by J. D. Cox.*

(*See Minutes of Proceedings.*)

The subject of photographing with the eye-piece in the microscope was discussed at the Chautauqua meeting, and references to it made in subsequent meetings led him to think the contention of Dr. Mercer's paper, as well as some former papers, to be based upon a misconception of what the speaker said in the first meeting referred to.

In advocating the use of the eye-piece in photomicrography he had done so chiefly because of the convenience in manipulation, for in this way high amplifications can be secured with a very moderate extension of the camera bellows; but he had also urged that the microscope is a compound optical instrument in which the objective is corrected for use with the eye-piece, and the substitution of an amplifier for the ocular involves the risk of combining parts that were not made for each other and are more likely to prove ill-adapted to each other.

The experience of Dr. Woodward had been referred to; but Dr. W. had left it on record that the amplifiers he specially ordered from distinguished opticians failed to give satisfactory results, one made by Tolles being the exception, and that apparently by accident, since others by the same maker did not work well.

Some papers formerly read before the Society seemed to argue that in the very nature of the case no sharp image is or can be

projected upon a screen when the eye-piece is used. To this the old refutation is offered, "*solvit eundo.*" Photographs of delicate objects made with use of eye-piece are produced and the image *is* sharp. Not to mention the speaker's own photographs of diatoms, Dr. Detmers had photographed *amphipleura pellucida* with the eye-piece by preference, and his prints challenged comparison with any ever made, as his were, by lamplight. Very recently Dr. Baker had photographed *pleurosigma angulatum* in a way to rival any results attained by anybody anywhere. It was done by lamp and with the eye-piece. The amplification in some of these instances reaches or exceeds 2,000 diameters. If the thing is thus done in fact, there must be some error in reasoning which concludes that it can't be done.

In listening attentively to Dr. Mercer, the speaker thought his reasoning proceeded on the supposition that the focusing of the microscope is not meddled with when the instrument is moved from the eye to the camera. It was astonishing that this should be assumed. Photographs have been exhibited and published of varying amplifications made with the same objective and eye-piece. The society cannot need to be reminded that these different amplifications imply different extensions of the camera bellows, and that for every change of such extension a change of focus of the microscope is necessary, on the fundamental and elementary principle that the lengthening of one of the conjugate foci of an optical lens or combination of lenses implies the shortening of the other.

If it was assumed that the focus used with the eye was retained in photographing with varying amplifications, it was a misconception which would be removed as soon as it was known to exist. The speaker certainly never dreamed that any one could suppose he had asserted that his work in photography was done in that way. The opponents of the use of the eye-piece have seemed to argue that it is theoretically impossible to produce an image on the screen by means of the whole microscope, objective and eye-piece combined. If they only meant to say that we cannot do so unless we focus the image properly on the screen, the debate has been almost ludicrously vain, as much so as to say that to see an object under the microscope with the eye we must focus for it and focus differently for different eyes.

In saying that the speaker used the microscope in photographing under the same conditions as in investigating, he meant that he used

the whole compound instrument, objective and ocular, with the illumination the same in kind and general adjustment. In transferring the instrument to the camera the place of the lamp is usually changed and the illumination has to be re-adjusted, but a pivoted support for lamp and microscope may be so arranged that the light will remain precisely as used for the eye. The focus, as already said, must be re-adjusted till the image is sharp upon the screen at the amplification and consequent extension of camera bellows determined upon.